CERTIFICATION OF TRANSLATION

I, ***Eun-mee Won***, an employee of Y.P. LEE, MOCK & PARTNERS of Koryo Bldg., 1575-1 Seocho-dong, Seocho-gu, Seoul, Republic of Korea, hereby declare under penalty of perjury that I understand the Korean language and the English language; that I am fully capable of translating from Korean to English and vice versa; and that, to the best of my knowledge and belief, the statement in the English language in the attached translation of ***Korean Patent Application No. 10-2002-0079755*** consisting of *41* pages, have the same meanings as the statements in the Korean language in the original document, a copy of which I have examined.

Signed this 8th day of May 2006

Eunmee Won

ABSTRACT

[Abstract of the Disclosure]

Provided are a disc and a method and apparatus for managing defects thereof using a defect management area that can be updated. The disc includes a user data area in which user data is recorded, a spare area that is a substitute for a defect existing in the user data area, and an area in which the address of data that is lastly recorded in the user data area and the address of a replacement recorded in the spare area are recorded. Accordingly, the disc defect management method and apparatus are applicable to a write once disc, while effectively using a defect management area of the disc.

[Representative Drawing]

FIG. 3B

SPECIFICATION

[Title of the Invention]

Method and Apparatus for Managing Disc Defects Using TDFL and TDDS, and Disc Therein

[Brief Description of the Drawings]

FIG. 1 is a block diagram of a recording apparatus according to a preferred embodiment of the present invention.

FIG. 2 illustrates structures of a disc according to preferred embodiments of the present invention.

FIG. 3A illustrates data structures of the disc of FIG. 2 according to a preferred embodiment of the present invention.

FIG. 3B illustrates a data structure of a disc with defect management areas (DMAs) and a temporary DMA (TDMA) as shown in FIG. 3A.

FIGS. 4A through 4D illustrate data structures of a TDMA according to preferred embodiments of the present invention.

FIG. 5A illustrates a data structure of temporary defect information *TDFL #i* according to a preferred embodiment of the present invention.

FIG. 5B illustrates a data structure of temporary defect information *TDFL #i* according to another embodiment of the present invention.

FIG. 6 illustrates a data structure of temporary defect management information *TDDS #i* according to a preferred embodiment of the present invention.

FIG. 7 illustrates diagrams explaining recording of data in a user data area *A* and a spare area *B*, according to a preferred embodiment of the present invention.

FIG. 8 is a diagram illustrating effective use of a data area according to the present invention.

FIG. 9 illustrates data structures of temporary defect information *TDFL #1* and *TDFL #2* recorded according to the recording of data shown in FIG. 7.

FIG. 10 illustrates a data structure of information regarding defect #i.;

FIG. 11 is a flowchart illustrating a disc defect management method according to a preferred embodiment of the present invention.

FIG. 12 is a flowchart illustrating a disc defect management method according to another embodiment of the present invention.

[Detailed Description of the Invention]

[Object of the Invention]

[Technical Field of the Invention and Related Art Prior to the Invention]

The present invention relates to disc defect management, and more particularly, to a disc and method and apparatus for managing defects therein using a temporary defect management area (TDMA).

Disc defect management is the process of rewriting data stored in a user data area of a disc in which a defect exists to a new portion of the disc's data area, thereby compensating for data loss caused by the defect. In general, disc defect management is performed using linear replacement or slipping replacement. In linear replacement, the user data area in which a defect exists is replaced with a spare data area having no defects. In slipping replacement, the user data area with the defect is slipped and the next user data area having no defects is used.

Both linear replacement and slipping replacement are, however, applicable only to discs such as a DVD-RAM/RW, on which data can be repeatedly recorded and recording can be performed using a random access method. In other words, linear replacement and slipping replacement are difficult to apply to write once discs on which recording is allowed only once. In general, the presence of defects in a disc is detected by recording data on the disc and confirming whether or not data has been recorded correctly on the disc. However, once data is recorded on a write once disc, it is impossible to overwrite new data and manage defects therein.

After the development of CD-R and DVD-R, a high-density write once disc with a recording capacity of several dozen GBs was introduced. This type of disc can be used as a backup disc since it is not expensive and allows random access that enables fast reading operations. However, disc defect management is not available for write once discs. Therefore, a backup operation may be discontinued when a defective area, i.e., an area where a defect exists, is detected during the backup operation. In general, a backup operation is performed when a system is not frequently used, e.g., at night when a system manager does not operate the system. In this case, it is more likely that the backup operation will be discontinued when because a defective area of a write once disc is detected.

[Technical Goal of the Invention]

The present invention provides a write once disc, and a disc defect management method and apparatus.

The present invention also provides a write once disc and a disc defect management method and apparatus that can manage disc defects even when a defect is detected during a recording operation, allowing the recording operation to be performed without interruption.

[Structure of the Invention]

According to an aspect of the present invention, there is provided a write once disc with a single layer in which a lead-in area, a data area, and a lead-out area are sequentially arranged, the disc comprising a defect management area being located in at least one of the lead-in area and the lead-out area; and a temporary defect management area being located in at least one of the lead-in area and the lead-out area, wherein the temporary defect management area stores temporary defect information repeatedly recorded for each recording operation, and temporary defect information, and the defect management area stores temporary defect information and temporary defect management information, which are finally recorded in the temporary defect management area during finalization, as defect information and defect management information, respectively.

According to another aspect of the present invention, there is provided a write once disc with a first layer in which a lead-in area, a data area, and a lead-out area are sequentially arranged, and a second layer in which an outer area, a data area, and a lead-out area are sequentially arranged, the disc comprising a defect management area being located in at least one of the lead-in area, the lead-out area, and the outer area; and a temporary defect management area being located in at least one of the lead-in area, the lead-out area, and the outer area, wherein the temporary defect management area stores temporary defect information repeatedly recorded for each recording operation, and temporary defect information, and the defect management area stores temporary defect information and temporary defect management information, which are finally recorded in the temporary defect management area during finalization, as defect information and defect management information, respectively.

The temporary defect management area may store an address of information lastly recorded in a user data corresponding to each layer and an address of

information lastly recorded in a spare area corresponding to each layer. The temporary defect management area may store a pointer pointing out to a location of the temporary defect information. The temporary defect management area may store temporary defect management information to correspond to the temporary defect information recorded for each recording operation.

The temporary defect information may comprise state information regarding a defect, a pointer pointing out to a location of the defect, and a pointer pointing out to a location of a replacement.

The state information may indicate whether the defect is a continuous defect block or a single defect block. The state information may indicate that the defect is in a continuous defect block, and the corresponding defect position pointer and replacement position pointer indicate the start position of the defect and the start position of the replacement, respectively. The state information may indicate that the defect is in a continuous defect block, and the corresponding defect position pointer and replacement position pointer indicate the end position of the defect and the end position of the replacement, respectively.

According to another aspect of the present invention, there is provided a method of managing defects in a disc, the method comprising (a) recording information regarding defects in data, which is recorded in a data area of the disc according to a first recording operation, as a plurality of first temporary defect information in a temporary defect management area located in at least one of a lead-in area and a lead-out area in the disc; (b) management information for managing the first temporary defect information as first temporary defect management information in the temporary defect management area; (c) repeatedly performing (a) and (b) at least once while increasing indexes given to the recording operation, the temporary defect information, and the temporary defect management information by 1; and (d) recording lastly recorded temporary defect management information and temporary defect information in a defect management area located in at least one of the lead-in area, the lead-out area, and an outer area in the disc.

(d) may be performed after recording data in the data area according to a last recording operation.

(a) may comprise sequentially recording the temporary defect information in a temporary defect information area in the temporary defect management area, starting from the start of the temporary defect information area. (b) may comprise sequentially

recording the temporary defect management information in a temporary defect information area in the temporary defect management area, starting from the start of the temporary defect information area. (a) may comprise sequentially recording the temporary defect information in a temporary defect information area in the temporary defect management area, starting from the end of the temporary defect information area. (b) may comprise sequentially recording the temporary defect management information in a temporary defect information area in the temporary defect management area, starting from the end of the temporary defect information area. (a) and (b) may comprise sequentially recording the corresponding temporary defect information and temporary defect management information as pairs of information in the temporary defect management area, starting from the start of the temporary defect management area. Otherwise, (a) and (b) may comprise sequentially recording the corresponding temporary defect information and temporary defect management information as pairs of information in the temporary defect management area, starting from the end of the temporary defect management area.

(a) may comprise (a1) recording data in predetermined units; (a2) verifying the recorded data to detect defects therein; (a3) storing information pointing out to a defect region where a defect occurs, and information pointing out to a region where a replacement region which replaces the defect region, as the first temporary defect information in a memory; (a4) repeatedly performing (a1) through (a3) at least once; and (a5) reading the information from the memory, and recording the read information as a plurality of the first temporary defect information in the temporary defect management area.

According to another aspect of the present invention, there is provided a recording apparatus comprising a recording/reproducing unit recording data on or reproducing data from a disc; and a controller controlling the recording/reproducing unit to repeatedly record information regarding defects in data, which is recorded in a data area of the disc according to a recording operation, as temporary defect information in a temporary defect management area located in at least one of a lead-in area and a lead-out area of the disc; and record management information for managing the temporary defect information as temporary defect management information in the temporary defect management area.

The controller may control the recording/reproducing unit to record the temporary defect information and the temporary defect management information in the

temporary defect management area for each recording operation; and record lastly recorded temporary defect information and temporary defect management information in a defect management area, which is located in at least one of the lead-in area and the lead-out area, during finalization.

According to another aspect of the present invention, there is provided a recording apparatus comprising a recording/reproducing unit recording data on or reproducing data from a disc; and a controller controlling the recording/reproducing unit to record information regarding defects in data, which is recorded in a data area of the disc according to a first recording operation, as a plurality of first temporary defect information in a temporary defect management information located in at least one of a lead-in area and a lead-out area of the disc; defect management information for managing the first temporary defect information as first temporary defect management information in the temporary defect management area; information regarding defects in data, which is recorded in the data area according to a second recording operation, as a plurality of second temporary defect information in the temporary defect management area; and defect management information for managing the second temporary defect information as second defect management information in the temporary defect management area.

The controller may control the recording/reproducing unit to record data in the data area while increasing indexes given to the recording operation, the temporary defect information, and the temporary defect management information by 1; and record lastly recorded temporary defect management information and temporary defect information in a defect management area located in at least one of the lead-in area, the lead-out area, and an outer area of the disc.

The controller may control the recording/reproducing unit to record data in the data area according to a last recording operation, and lastly recorded temporary defect information and temporary defect management information corresponding to the recording operation as final defect management information and defect information in a defect management area located in at least one of the lead-in area, the lead-out area, and an outer area of the disc.

The controller may control the recording/reproducing unit to sequentially record the defect information in a defect information area in the defect management area starting from the start of the defect information area. The controller may control the recording/reproducing unit to sequentially record the defect management information in

a defect information management area in the defect management area starting from the start of the defect information management area. The controller may control the recording/reproducing unit to sequentially record the defect information in a defect information area in the defect management area starting from the end of the defect information area. The controller may control the recording/reproducing unit to sequentially record the defect management information in a defect information management area in the defect management area starting from the end of the defect information management area. The controller may control the recording/reproducing unit to sequentially record the corresponding defect information and defect management information as pairs of information in the defect management area starting from the start of the defect management area. The controller may control the recording/reproducing unit to sequentially record the corresponding defect information and defect management information as pairs of information in the defect management area starting from the end of the defect management area.

The recording apparatus may further include a memory. The controller may control the recording/reproducing unit to record data in specific units according to a specific recording operation; verify the recorded data to detect defects therein; create information pointing out to a defect area where a defect occurs and information pointing out to an area which replaces the defect area and stores them as temporary defect information in the memory; control the recording/reproducing unit to record the data, which is recorded according to the specific recording operation, in specific units after the defect area; read the temporary defect information from the memory after the data is recorded according to the specific recording operation; and provide the read information to the recording/reproducing unit so that the read information is to be recorded in the temporary defect management area.

FIG. 1 is a block diagram of a recording apparatus according to a preferred embodiment of the present invention. Referring to FIG. 1, the recording apparatus includes a recording/reading unit 1, a controller 2, and a memory 3. The recording/reading unit 1 records data on a disc 100, an information storage medium according to a preferred embodiment of the present invention, and reads back the data from the disc 100 to verify the accuracy of the recorded data. The controller 2 performs disc defect management according to the present invention. In this embodiment, the controller 2 uses a verify-after-write method in which data is recorded on the disc 100 in predetermined units of data and the accuracy of the recorded data is

verified to detect if an area of the disc 100 has a defect. In other words, the controller 2 records user data on the disc 100 in units of recording operations and verifies the recorded user data to detect an area of the disc 100 in which a defect exists. Thereafter, the controller 2 creates information that indicates the position of the area with the defect and stores the created information in the memory 3, and stores the information in the memory 3. When the amount of the stored information reaches a predetermined level or the verify-after-write operation is performed a predetermined number of times, the controller 2 records the stored information as temporary defect information on the disc 100.

Here, the recording operation is a unit of work determined according to a user's intention or is a recording work to be performed. According to this embodiment, a recording operation indicates a process in which the disc 100 is loaded into the recording apparatus, data is recorded on the disc 100, and the disc 100 is taken out from the recording apparatus. During the recording operation, data is recorded and verified at least once; in general, data is recorded and verified several times. Defect information, which is obtained using the verify-after-write method, is temporarily stored as temporary defect information in the memory 3.

When a user presses the eject button (not shown) of the recording apparatus in order to remove the disc 100 after recording of data, the controller 2 expects the recording operation to be terminated. Next, the controller 2 reads the information from the memory 3, provides it to the recording/reading unit 1, and controls the recording/reading unit 1 to record it on the disc 100.

When the recording of data is completed, i.e., additional data will not be recorded on the disc 100 (the disc 100 needs to be finalized), the controller 2 controls the recording/reading unit 1 to rewrite the recorded temporary defect information and temporary defect management information to a defect management area (DMA) of the disc 100 as defect management information.

FIG. 2 illustrates structures of the disc 100 of FIG. 1 according to preferred embodiments of the present invention. FIG. 2(a) illustrates in detail a single record layer disc representation of disc 100 having a record layer *L0*. The disc 100 includes a lead-in area, a data area, and a lead-out area. The lead-in area is located in an inner part of the disc 100 and the lead-out area is located in an outer part of the disc 100. The data area is present between the lead-in area and the lead-out area and divided into a user data area and a spare area.

The user data area is an area where user data is recorded, and the spare area is a replacement area for a user data area having a defect, serving to compensate for loss in the recording area due to the defect. On the assumption that defects may occur within the disc 100, it is preferable that the spare area assumes about 5% of the entire data capacity of the disc 100, so that a greater amount of data can be recorded on the disc 100.

FIG. 2(b) illustrates a double record layer disc representation of disc 100 having two record layers *L0* and *L1*. A lead-in area, a data area, and an outer area are sequentially formed from the inner part of the first record layer *L0* to its outer part. Also, an outer area, a data area, and a lead-out area are sequentially formed from the outer part of the second record layer *L1* to its inner part. Unlike the single record layer disc of FIG. 2(a), the lead-out area is present in the inner part of the disc 100 of FIG. 2(b). That is, the disc 100 of FIG. 2(b) has an opposite track path (OTP) in which data is recorded starting from the lead-in area of the first record layer *L0* toward its outer area and continuing from the outer area of the second record layer *L1* to its lead-out area. The spare area is allotted to each of the record layers *L0* and *L1*.

In this embodiment, the spare areas are present between the user data area and the lead-out area and between the user data area and the outer area. If necessary, a portion of the user data area may be used as another spare area, that is, more than one spare area may be present between the lead-in area and the lead-out area.

FIG. 3A illustrates structures of the disc 100 of FIG. 2, according to a preferred embodiment of the present invention. Referring to FIG. 3A, if the disc 100 is a single record layer disc, at least one DMA is present in the lead-in area and the lead-out area of the disc 100, and at least one temporary defect management area (TDMA) is also present in the lead-in area and the lead-out area. If the disc 100 is a double record layer disc, at least one DMA is present in the lead-in area, the lead-out area, and the outer area, and at least one TDMA is present in the lead-in area and the lead-out area. In the case of the double record layer disc shown in FIG. 2B, the DMA and the TDMA are preferably formed in the lead-in area and the lead-out area, which are located in the inner part of the disc 100, respectively.

In general, information relating to managing disc defects in the disc 100 is recorded in the DMA. Such information includes the structure of the disc 100 for disc defect management, the recording position of defect information, whether defect

management is performed or not, and the position and size of a spare area. In the case of a write once disc, when the above information changes, new data is recorded after previously recorded data.

In general, when a disc is loaded into a recording/reading apparatus, the apparatus reads data from a lead-in area and a lead-out area of the disc to determine how to manage the disc and record data on or read data from the disc. However, if the amount of data recorded in the lead-in area and/or the lead-out area increases, a longer time is spent on preparing the recording or reproducing of data after the loading of the disc. To solve this problem, the present invention adopts temporary defect management information and temporary defect information that are to be recorded in a TDMA. The TDMA is allotted to the lead-in area and/or the lead-out area of a disc, being separated from the DMA. That is, only lastly recorded defect information and defect management information, which are required to perform disc defect management, are recorded in the DMA, thereby reducing the amount of information that the recording/reading unit requires for a recording/reproducing operation.

In this embodiment, since disc defect management is performed using linear replacement, the temporary defect information includes information indicating the position of an area of the disc 100 having a defect and information indicating the position of an area of the disc 100 that is replacement for the area having the defect. More preferably, the temporary defect information further includes information indicating whether the area having the defect is a single defect blocks or a continuous defect block. The temporary defect management information is used to manage the temporary defect information and includes information indicating the position of the disc 100 where the temporary defect information is recorded. More preferably, the temporary defect management information further includes information indicating the position of user data that is lastly recorded in the user data area and a replacement area that is lastly formed in a spare area. Detailed data structures of temporary defect information and temporary defect management information will be explained later.

In this embodiment, the temporary defect information and temporary defect management information are recorded every time when a recording operation ends. In the TDMA, information regarding a defect, which occurs in data recorded during recording operation #0, and information regarding a replacement area are recorded as temporary defect information #0, and information regarding a defect, which occurs in data recorded during recording operation #1, and information regarding a replacement

area are recorded as temporary defect information #1. Further, information for managing temporary defect information #0, #1, ... is recorded as temporary defect management information #0, #1, ... in the TDMA. When additional data cannot be recorded in the data area or a user does not wish to record additional data therein, i.e., the data needs to be finalized, temporary defect information recorded in a temporary defect information area and temporary defect management information recorded in a temporary defect management information area are rewritten to the DMA.

The temporary defect information and the temporary defect management information are rewritten to the DMA for the following reason. In the case that additional data will not be recorded on the disc 100, i.e., the disc 100 needs to be finalized, only lastly recorded ones of the temporary defect management information and temporary defect information, which have been updated several times, are again recorded in the DMA. Thus, the recording/reading unit 1 can read fast defect management information from the disc 100 just by reading the lastly recorded defect management information, thereby enabling fast initializing of the disc 100. Further, recording of the temporary defect information and temporary defect management information in the DMA increases the reliability of information.

In this embodiment, defect information contained in previously recorded temporary defect information #0, #1, #2,..., and #i-1 is further contained in temporary defect information #i. Thus, it is easy to finalize the disc 100 just by reading defect information contained in lastly recorded temporary defect information #i and rewrite the read defect information to the DMA.

In the case of a high-density disc with a recording capacity of several dozens of GBs, it is desirable that a cluster is allocated to an area in which temporary defect management information #i is recorded and four to eight clusters are allocated to an area in which temporary defect information #i is recorded. This is because it is preferable to record new information in units of clusters to update information when a minimum physical unit of record is a cluster, although the amount of temporary defect information #i is just several KBs. A total amount of defects allowed in a disc is preferably about 5 percentage of the disc recording capacity. For instance, about four to eight clusters are required to record temporary defect information #i, considering that information regarding a defect is about 8 bytes long and the size of a cluster is 64 KBs long.

The verify-after-write method can also be performed on temporary defect

information #i and temporary defect management information #i. When a defect is detected, information recorded in an area of a disc having a defect may be either recorded in a spare area using linear replacement, or recorded in an area adjacent to the TDMA using slipping replacement.

FIG. 3B illustrates a data structure of a disc with a TDMA and DMAs as shown in FIG. 3A. If the disc is a single record layer as shown in FIG. 2A, the TDMA and the DMA are present in at least one of a lead-in area and a lead-out area of the disc. If the disc is a double record layer disc as shown in FIG. 2B, the TDMA and the DMA are present in at least one of a lead-in area, a lead-out area, and an outer area, more preferably, the TDMA and the DMA are present in the lead-in area and the lead-out area, respectively.

Referring to FIG. 3B, two DMAs are formed to increase the robustness of defect management information and defect information. In FIG. 3B, *TDMA* denotes a temporary defect management area; *Test* denotes an area in which recording conditions of data are measured; *Drive and Disc information* is an area in which information regarding a drive used during a recording and/or reproducing operation(s) and disc information indicating whether a disc is a single record layer disc or a double record layer are recorded; *Buffer 1*, *Buffer 2*, and *Buffer 3* are areas that act as buffers that indicate borders of the respective areas.

FIGS. 4A through 4D illustrate data structures of a TDMA according to preferred embodiments of the present invention.

Referring to FIG. 4A, a TDMA is logically divided into a temporary defect information area and a temporary defect management information area. In the temporary defect information area, temporary defect information *TDFL #0*, *TDFL #1*, *TDFL #2*, ... is sequentially recorded starting from the start of this area toward its end. The temporary defect information *TDFL #0*, *TDFL #1*, *TDFL #2*, ... is repeatedly recorded several times to increase the robustness of information. In particular, FIG. 4A illustrates recording of the temporary defect information *TDFL #0* P times. In the temporary defect management information area, temporary defect management information *TDDS #0*, *TDDS #1*, *TDDS #2*, ... is sequentially recorded starting from the start of this area. The temporary defect management information *TDDS #0*, *TDDS #1*, and *TDDS #2* correspond to the temporary defect information *TDFL #0*, *TDFL #1*, and *TDFL #2*, respectively.

Referring to FIG. 4B, compared to FIG. 4A, a DMA is also logically divided into a

temporary defect information area and a temporary defect management information area, but the sequences of recording information are not the same. More specifically, in the temporary defect information area, temporary defect information *TDFL #0, TDFL #1, TDFL #2*, ... is sequentially recorded starting from the end of this area toward its start. Similarly, the temporary defect information *TDFL #0*, *TDFL #1*, *TDFL #2*, ... is repeatedly recorded several times to increase the robustness of information. In particular, FIG. 4B illustrates recording of the temporary defect information *TDFL #0* P times. In the temporary defect management information area, temporary defect management information *TDDS #0, TDDS #1, TDDS #2*, ... is sequentially recorded starting from the end of this area. The temporary defect management information *TDDS #0, TDDS #1*, and *TDDS #2* correspond to the defect information *TDFL #0*, *TDFL #1*, and *TDFL #2*, respectively.

Referring to FIG. 4C, corresponding temporary defect information and temporary defect management information are recorded as pairs of information in a TDMA. More specifically, temporary management information *TDMA #0, TDMA #1,* ... is sequentially recorded starting from the start of the TDMA. The temporary management information *TDMA #0* contains a pair of corresponding temporary defect management *TDDS #0* and temporary defect information *TDFL #0,* and temporary management information *TDMA #1* contains a pair of corresponding temporary defect management information *TDDS #1* and temporary defect information *TDFL #1*. The temporary defect information *TDFL #0*, *TDFL #1*, *TDFL #2*, ... are repeatedly recorded several times to increase the robustness of information. In particular, FIG. 4C illustrates recording of the temporary defect information *TDFL #0* P times.

Referring to FIG. 4D, compared to the TDMA of FIG. 4C, corresponding temporary defect information and temporary defect management information are recorded as pairs of information in a TDMA, but the sequence of recording the information is not the same. More specifically, in the TDMA, temporary management information *TDMA #0*, *TDMA #1*, ... is sequentially recorded starting from the end of the TDMA. The temporary management information *TDMA #0* contains a pair of corresponding temporary defect management information *TDDS #0* and temporary defect information *TDFL #0*, and the temporary management information *TDMA #1* contains a pair of corresponding temporary defect management information *TDDS #1* and temporary defect information *TDFL #1*. Similarly, the temporary defect information *TDFL #0*, *TDFL #1*, *TDFL #2*, ... is repeatedly recorded several times to

increase the robustness of information. In particular, FIG. 4D illustrates recording of the temporary defect information *TDFL #0* P times.

FIGS. 5A and 5B illustrate data structures of temporary defect management information *TDDS #i*. In detail, FIG. 5A illustrates a data structure of temporary defect management information *TDDS #i* recorded on a single record layer disc. The temporary defect management information *TDDS #i* contains an identifier for temporary defect management information *TDDS #i*, and information regarding the position of corresponding temporary defect information *TDFL #i*. As previously explained with reference to FIGS. 4A through 4D, temporary defect information *TDFL #i* according to the present invention is repeatedly recorded several times, and thus, the information regarding the position of temporary defect information *TDFL #i* includes pointers corresponding to temporary defect information *TDFL #i*, each pointer pointing out to the recording position of each temporary defect information *TDFL #i*. Temporary defect management information *TDDS #i* shown in FIG. 5A includes P pointers for temporary defect information *TDFL #i* recorded P times.

Also, temporary defect management information *TDDS #i* recorded on a single record layer disc describes the address of user data, which is lastly recorded in a user data area of a record layer *L0*, and the address of replacement which is lastly recorded in a spare area of the record layer *L0*. Accordingly, a user can easily utilize the disc just by referring to the lastly recorded user data and replacement.

FIG. 5B illustrates a data structure of temporary defect management information *TDDS #i* recorded on a double record layer disc. Temporary defect management information *TDDS #i* contains an identifier for temporary defect management information *TDDS #i*, and information regarding the recording position of corresponding temporary defect information *TDFL #i*. As previously mentioned with reference to FIGS. 4A through 4D, temporary defect information *TDFL #i* according to the present invention is repeatedly recorded several times, and thus, the information regarding the recording position of temporary defect information *TDFL #i* contains pointers pointing out to the recording positions of respective temporary defect information *TDFL #i*. In particular, temporary defect management information *TDDS #i* shown in FIG. 5B includes P pointers, each pointer pointing out each of temporary defect information *TDFL #i* that is repeatedly recorded P times.

Also, temporary defect management information *TDDS #i* recorded on a double record layer disc describes the address of user data that is lastly recorded in a user

data area of a first record layer *L0*, the address of replacement that is lastly recorded in a spare area of the first record layer *L0*, the address of user data that is lastly recorded in a user data area of a second record layer *L1*, and the address of replacement that is lastly recorded in a spare area of the second record layer L1. Accordingly, a user can easily utilize the disc just by referring to the lastly recorded user data and replacement.

FIG. 6 illustrates a data structure of temporary defect information *TDFL #i*. Referring to FIG. 6, temporary defect information *TDFL #i* contains an identifier for temporary detect information *TDFL #i*, and information regarding defects #1, #2, ..., and #K. The information regarding defects #1, #2, ..., and #K is state information indicating the positions of defects and replacements, and whether a defective area is a single defect block or a continuous defect block.

FIG. 7 is a diagram illustrating in detail recording of data in a user data area *A* and a spare area *B*, according to a preferred embodiment of the present invention.

Data can be processed in units of sectors or clusters. A sector denotes a minimum unit of data that can be managed in a file system of a computer or in an application, and a cluster denotes a minimum unit of data that can be physically recorded on a disc at once. In general, one or more sectors constitute a cluster.

There are two types of sectors: a physical sector and a logical sector. The physical sector is an area on a disc where a sector of data is to be recorded. An address for detecting the physical sector is called a physical sector number (PSN). The logical sector is a unit in which data can be managed in a file system or an application. An address for detecting the logical sector is called a logical sector number (LSN). A disc recording/reading apparatus detects the recording position of data on a disc using a PSN. In a computer or an application relating to data, the entire data is managed in units of LSNs and the position of data is detected using an LSN. The relationship between an LSN and a PSN is changed by a controller of the recording/reading apparatus, based on whether or not the disc contains a defect and an initial position of recording data.

Referring to FIG. 7, *A* denotes a user data area and *B* denotes a spare area in which PSNs are sequentially allocated to a plurality of sectors (not shown). In general, each LSN corresponds to at least one PSN. However, since LSNs are allocated to non-defective areas, including replacements recorded in the spare area, the correspondence between the PSNs and the LSNs is not maintained when a disc has a defective area, even if the size of a physical sector is the same as that of a logical

sector.

In the user data area *A*, user data is recorded either in a continuous recording mode or a random recording mode. In the continuous recording mode, user data is recorded sequentially and continuously. In the random recording mode, user data is randomly recorded. In the data area *A*, sections ① through ⑦ denote predetermined units of data in which the verify-after-write method is performed. A recording apparatus records user data in section ①, returns to the start of section ①, and checks if the user data is appropriately recorded or a defect exists in section ①. If a defect is detected in a portion of section ①, the portion is designated as defect #1. The user data recorded in defect #1 is also recorded on a portion of the spare area *B*. Here, the portion of the spare area *B* in which data recorded in defect #1 is rewritten is called replacement #1. Next, the recording apparatus records user data in section ②, returns to the start of section ②, and checks whether the data is properly recorded or a defect exists in section ②. If a defect is detected in a portion of section ②, the portion is designated as defect #2. Likewise, replacement #2 corresponding to defect #2 is formed in the spare area *B*. Further, defect #3 and replacement #3 are designated in section ③ of the user data area *A* and the spare area *B*, respectively. In section ④, a defect does not occur and a defective area is not designated.

The recording apparatus records information regarding defect #1, #2, and #3 occurring in sections ① through ④ as temporary defect information *TDFL #0* in a TDMA, when recording operation #0 is expected to end, after the recording and verifying of data to section ④, i.e., when a user presses the eject button of a recording apparatus or recording of user data allocated in a recording operation is complete. Also, management information for managing temporary defect information *TDFL #0* is recorded as temporary defect management information *TDDS #0* in the TDMA.

When recording operation #1 starts, data is recorded in sections ⑤ through ⑦ and defects #4 and #5 and replacements #4 and #5 are formed in the user data area *A* and the spare area *B*, respectively, as explained in sections ① through ④. Defects #1, #2, #3, and #4 occur in the single blocks, whereas defect #5 occurs in is a continuous defect block. Replacement #5 is a continuous replacement block that is replacement for defect #5. Here, a block refers to a physical or logical record unit, a range of a unit block being not limited. If the second recording operation is expected to end, the recording apparatus records information regarding defects #4 and #5 as temporary defect information *TDFL #1*, and records the information contained in the

defect information *DFL #1* once again. Thereafter, management information for managing temporary defect information *TDFL #1* is recorded as temporary defect management information #1 in the TDMA.

FIG. 8 is a diagram illustrating effective use of a user data area according to the present invention. FIG. 8 reveals that an available portion of a user data area can easily be detected with the address of user data that is lastly recorded in the user data area and the address of replacement that is lastly recorded in the spare area. In particular, the available portion can be more easily detected, when the user data is recorded from the inner part/outer part of the user data area to its outer part/inner part and data, which is replacement for a defect, is recorded from the outer part/inner part of the spare area to its inner part/outer part, respectively. In other words, the user data and the data for replacement are preferably recorded in the opposite recording direction.

When physical addresses of user data are increased from the inner part of the record layer *L0* to the outer part and increased from the outer part of the record layer *L1* to the inner part, a physical address of the data, which is lastly recorded in the user data areas of record layers *L0* and *L1*, has the largest number. Also, lastly recorded replacement has a physical address with the smallest number, when physical addresses of replacements are reduced from the outer part to the inner part in a spare area of the record layer *L0* and increased from the inner part to the outer part in a spare area of the record layer *L1*.

Accordingly, as previously mentioned, if the addresses of the lastly recorded data and replacement are included in temporary defect management information *TDDS #i*, it is possible to detect the positions of data and replacement that are to be newly recorded, without completely reading temporary defect information *TDFL #i* and estimating the positions of defect and replacement. Further, available portions of the user data area and the spare area are located continuously, thereby enabling effective use of the user area.

FIG. 9 illustrates data structures of temporary defect information *TDFL #0* and *TDFL #1* recorded as explained with respect to FIG. 7. FIG. 10 illustrates a data structure of information regarding defect #i recorded as explained with reference to FIG. 7.

Referring to FIG. 9, temporary defect information *TDFL #0* contains information regarding defects #1, #2, and #3. The information regarding defect #1 indicates the

position of an area in which defect #1 exists and the position of an area in which replacement #1 is recorded. The information regarding defect #1 may further include information indicating whether defect #1 is a continuous defect block or a single defect block. Likewise, the information regarding defect #2 indicates whether defect #2 is a continuous defect block or a single defect block, the position of an area in which defect #2 exists. and the position of an area in which replacement #2 is recorded. The information regarding defect #3 indicates whether defect #3 is a continuous defect block or a single defect block, the position of an area in which defect #3 exists, and the position of an area in which replacement #3 is recorded.

Temporary defect information *TDFL #1* further contains information regarding defects #4 and #5 in addition to the information contained in temporary defect information *TDFL #0*. More specifically, temporary defect information *TDFL #1* includes the information regarding defect #1, the information regarding defect #2, the information regarding defect #3, the information regarding defect #4, and the information regarding defect #5.

Referring to FIG. 10, information regarding defect #i includes state information indicating whether defect #i is a continuous defect block or a single defect block, a pointer pointing out to defect #i, and a pointer pointing out to replacement #i. When defect #i is determined to be in a continuous defect block, the state information further represents whether a pointer for defect #i points out to the start or end of the continuous defect block and whether a pointer for replacement #i points out to the start or end of a replacement block that replaces defect #i. When the state information indicates the pointer for defect #i as the start of the continuous defect block and the pointer for replacement #i as the start of the replacement block, the pointer for defect #i represents a starting physical sector number of the continuous defect block and the pointer for replacement #i represent a starting physical sector number of replacement #i. In contrast, when the state information indicates the pointer for defect #i as the end of the continuous defect block and the pointer for replacement #i as the end of the replacement block, the pointer for defect #i represents an ending physical sector number of the continuous defect block and the pointer for replacement #i represent an ending physical sector number of replacement #i. The definition of a continuous defect block using state information enables effectively recording of information and saves a space of recording, even if information regarding defects is not recorded in units of blocks.

The pointer for defect #i specifies a starting and/or ending point(s) of defect #i. The pointer for defect #i may include a starting PSN of defect #i. The pointer for replacement #i specifies a starting and/or ending points of replacement #i. The pointer for replacement #i may also include a starting PSN of replacement #i.

Hereinafter, a disc defect management method according to a preferred embodiment of the present invention will be described with reference to the accompanying drawings.

FIG. 11 is a flowchart illustrating a disc defect management method according to a preferred embodiment of the present invention. Referring to FIG. 11, in action 1101, a recording apparatus records defect information regarding data, which is recorded according to a first recording operation, as first temporary defect information in a TDMA of a disc. This process serves to manage disc defects. In action 1102, the recording apparatus records management information for managing the first temporary defect information as first temporary defect management information in the TDMA.

In action 1103, it is checked whether finalizing of the disc is required. In action 1104, if it is determined in action 1103 that the finalizing of the disc is not required, actions 1101 and 1102 are repeated while increasing indexes given to a recording operation, temporary defect information, and temporary defect management information by 1. However, if it is determined in action 1103 that the finalizing of the disc is required, lastly recorded temporary defect management information and temporary defect information are recorded in a DMA, in action 1105. That is, the lastly recorded temporary defect management information and temporary defect information are recorded as the final defect management information and defect information in the DMA, respectively. The final defect information and defect management information may be repeatedly recorded to increase the reliability of data detection. Further, the verify-after-write method may be performed on the final temporary defect management information and temporary defect information. If a defect is detected from this information, an area of the disc having the defect and the following area containing data may be regarded as being unavailable, i.e., they are designated as a defective area, and the final temporary defect management information and temporary defect information may be again recorded after the defective area.

FIG. 12 is a flowchart illustrating a disc defect management method according to another embodiment of the present invention. Referring to FIG. 12, in action 1201, a

recording apparatus records user data in a data area of a disc in units of data to facilitate the verify-after-write method. In action 1202, the data recorded in action 1201 is verified to detect an area of the disc having a defect. In action 1203, the controller 2 of FIG. 1 designates the area having the defect as a defective area, controls the recording/reading unit 1 to rewrite data recorded in the defective area to a spare area so as to create a replacement area, and creates state information specifying whether the defective area is a single defect block or a continuous defect block, and pointer information that points out to the positions of the defective area and the replacement area. In action 1204, the state information and the pointer information as stored as first temporary defect information. In action 1205, it is checked whether the first recording operation is expected to end. If it is determined in action 1205 that the first recording operation is not expected to end, actions 1201 through 1204 are repeated.

In action 1206, if it is determined in action 1205 that the first recording operation is likely to end, i.e., when the recording of the user data is complete by user input or according to the first recording operation, the stored temporary defect information is read and repeatedly recorded as first temporary defect information *TDFL #0* in a TDMA several times. In action 1207, management information for managing the first temporary defect information *TDFL #0* is recorded as first temporary defect management information *TDDS #0* in the TDMA. In action 1208, it is checked whether the data needs to be finalized. If it is determined in action 1208 that the finalizing of the disc is not required, actions 1201 through 1207 are repeated. In action 1209, whenever actions 1201 through 1207 are repeated, indexes given to a recording operation, temporary defect information *TDFL*, and temporary defect management information *TDDS* are increased by 1. In action 1210, if it is determined in action 1208 that the finalizing of the disc is needed, lastly recorded temporary defect information *TDFL #i* and temporary defect management information *TDDS #i* are recorded as the final defect information *DFL* and the final defect management information *DDS* in the DMA. Recording of the final defect information *DFL* and the final defect management information *DDS* may be repeated several times to increase the reliability of data detection. Similarly, the verify-after-write method may be performed on the final defect information and defect management information. If a defect is detected in this information, an area of the disc having the defect and the following area containing data may be regarded as being unavailable, i.e., they are

designated as a defective area, and the final temporary defect management information and temporary defect information may be again recorded after the defective area.

[Effect of the Invention]

As described above, the present invention provides a disc defect management method that is applicable to write once discs. According to the present invention, at least one temporary defect information area is present in a lead-in area of a disc and/or a lead-out area, so that information regarding a defect that exists in the disc can be accumulatively recorded. Also, it is easy to finalize the disc by reading only lastly recorded temporary defect information from a temporary defect information area and recording the read information in a defect management area, thereby enabling effective use of the DMA. Accordingly, user data can be recorded even on write once discs while performing disc defect management, thereby performing backup operations more stably without interruptions.

What is claimed:

1. A write once disc with a single layer in which a lead-in area, a data area, and a lead-out area are sequentially arranged, the disc comprising:

a defect management area being located in at least one of the lead-in area and the lead-out area; and

a temporary defect management area being located in at least one of the lead-in area and the lead-out area,

wherein the temporary defect management area stores temporary defect information repeatedly recorded for each recording operation, and temporary defect information, and

the defect management area stores temporary defect information and temporary defect management information, which are finally recorded in the temporary defect management area during finalization, as defect information and defect management information, respectively.

2. A write once disc with a first layer in which a lead-in area, a data area, and a lead-out area are sequentially arranged, and a second layer in which an outer area, a data area, and a lead-out area are sequentially arranged, the disc comprising:

a defect management area being located in at least one of the lead-in area, the lead-out area, and the outer area; and

a temporary defect management area being located in at least one of the lead-in area, the lead-out area, and the outer area,

wherein the temporary defect management area stores temporary defect information repeatedly recorded for each recording operation, and temporary defect information, and

the defect management area stores temporary defect information and temporary defect management information, which are finally recorded in the temporary defect management area during finalization, as defect information and defect management information, respectively.

3. The disc of claim 1 or 2, wherein a plurality of the defect management areas are included in an area.

4. The disc of claim 1 or 2, wherein the temporary defect management area

stores an address of information lastly recorded in a user data corresponding to each layer and an address of information lastly recorded in a spare area corresponding to each layer.

5. The disc of claim 1 or 2, wherein the temporary defect management area stores a pointer pointing out to a location of the temporary defect information.

6. The disc of claim 1 or 2, wherein the temporary defect management area stores temporary defect management information to correspond to the temporary defect information recorded for each recording operation.

7. The disc of claim 1 or 2, wherein the temporary defect information comprises state information regarding a defect, a pointer pointing out to a location of the defect, and a pointer pointing out to a location of a replacement.

8. The disc of claim 7, wherein the state information indicates whether the defect is a continuous defect block or a single defect block.

9. The disc of claim 7, wherein the state information indicates that the defect is in a continuous defect block, and

the corresponding defect position pointer and replacement position pointer indicate the start position of the defect and the start position of the replacement, respectively.

10. The disc of claim 7, wherein the state information indicates that the defect is in a continuous defect block, and

the corresponding defect position pointer and replacement position pointer indicate the end position of the defect and the end position of the replacement, respectively.

11. A method of managing defects in a disc, comprising:

(a) recording information regarding defects in data, which is recorded in a data area of the disc according to a first recording operation, as a plurality of first temporary defect information in a temporary defect management area located in at least one of a

lead-in area and a lead-out area in the disc;

(b) management information for managing the first temporary defect information as first temporary defect management information in the temporary defect management area;

(c) repeatedly performing (a) and (b) at least once while increasing indexes given to the recording operation, the temporary defect information, and the temporary defect management information by 1; and

(d) recording lastly recorded temporary defect management information and temporary defect information in a defect management area located in at least one of the lead-in area, the lead-out area, and an outer area in the disc.

12. The disc of claim 11, wherein (d) is performed after recording data in the data area according to a last recording operation.

13. The disc of claim 11 or 12, wherein (a) comprises sequentially recording the temporary defect information in a temporary defect information area in the temporary defect management area, starting from the start of the temporary defect information area.

14. The disc of claim 13, wherein (b) comprises sequentially recording the temporary defect management information in a temporary defect information area in the temporary defect management area, starting from the start of the temporary defect information area.

15. The disc of claim 11 or 12, wherein (a) comprises sequentially recording the temporary defect information in a temporary defect information area in the temporary defect management area, starting from the end of the temporary defect information area.

16. The disc of claim 15, wherein (b) comprises sequentially recording the temporary defect management information in a temporary defect information area in the temporary defect management area, starting from the end of the temporary defect information area.

17. The disc of claim 11 or 12, wherein (a) and (b) comprise sequentially recording the corresponding temporary defect information and temporary defect management information as pairs of information in the temporary defect management area, starting from the start of the temporary defect management area.

18. The disc of claim 11 or 12, wherein (a) and (b) comprise sequentially recording the corresponding temporary defect information and temporary defect management information as pairs of information in the temporary defect management area, starting from the end of the temporary defect management area.

19. The disc of claim 11 or 12, wherein (a) comprises:

(a1) recording data in predetermined units;

(a2) verifying the recorded data to detect defects therein;

(a3) storing information pointing out to a defect region where a defect occurs, and information pointing out to a region where a replacement region which replaces the defect region, as the first temporary defect information in a memory;

(a4) repeatedly performing (a1) through (a3) at least once; and

(a5) reading the information from the memory, and recording the read information as a plurality of the first temporary defect information in the temporary defect management area.

20. A recording apparatus comprising:

a recording/reproducing unit recording data on or reproducing data from a disc; and

a controller controlling the recording/reproducing unit to repeatedly record information regarding defects in data, which is recorded in a data area of the disc according to a recording operation, as temporary defect information in a temporary defect management area located in at least one of a lead-in area and a lead-out area of the disc; and record management information for managing the temporary defect information as temporary defect management information in the temporary defect management area.

21. The recording apparatus of claim 20, wherein the controller controls the recording/reproducing unit to record the temporary defect information and the

temporary defect management information in the temporary defect management area for each recording operation; and record lastly recorded temporary defect information and temporary defect management information in a defect management area, which is located in at least one of the lead-in area and the lead-out area, during finalization.

22. A recording apparatus comprising:

a recording/reproducing unit recording data on or reproducing data from a disc; and

a controller controlling the recording/reproducing unit to record information regarding defects in data, which is recorded in a data area of the disc according to a first recording operation, as a plurality of first temporary defect information in a temporary defect management information located in at least one of a lead-in area and a lead-out area of the disc; defect management information for managing the first temporary defect information as first temporary defect management information in the temporary defect management area; information regarding defects in data, which is recorded in the data area according to a second recording operation, as a plurality of second temporary defect information in the temporary defect management area; and defect management information for managing the second temporary defect information as second defect management information in the temporary defect management area.

23. The recording apparatus of claim 22, wherein the controller controls the recording/reproducing unit to record data in the data area while increasing indexes given to the recording operation, the temporary defect information, and the temporary defect management information by 1; and record lastly recorded temporary defect management information and temporary defect information in a defect management area located in at least one of the lead-in area, the lead-out area, and an outer area of the disc.

24. The recording apparatus of claim 22 or 23, wherein the controller controls the recording/reproducing unit to record data in the data area according to a last recording operation, and lastly recorded temporary defect information and temporary defect management information corresponding to the recording operation as final defect management information and defect information in a defect management area located in at least one of the lead-in area, the lead-out area, and an outer area of the

disc.

25. The recording apparatus of claim 22 or 23, wherein the controller controls the recording/reproducing unit to sequentially record the defect information in a defect information area in the defect management area starting from the start of the defect information area.

26. The recording apparatus of claim 25, wherein the controller controls the recording/reproducing unit to sequentially record the defect management information in a defect information management area in the defect management area starting from the start of the defect information management area.

27. The recording apparatus of claim 22 or 23, wherein the controller controls the recording/reproducing unit to sequentially record the defect information in a defect information area in the defect management area starting from the end of the defect information area.

28. The recording apparatus of claim 27, wherein the controller controls the recording/reproducing unit to sequentially record the defect management information in a defect information management area in the defect management area starting from the end of the defect information management area.

29. The recording apparatus of claim 22 or 23, wherein the controller controls the recording/reproducing unit to sequentially record the corresponding defect information and defect management information as pairs of information in the defect management area starting from the start of the defect management area.

30. The recording apparatus of claim 22 or 23, wherein the controller controls the recording/reproducing unit to sequentially record the corresponding defect information and defect management information as pairs of information in the defect management area starting from the end of the defect management area.

31. The recording apparatus of claim 22 or 23, further comprising a memory, wherein the controller controls the recording/reproducing unit to record data in

specific units according to a specific recording operation; verifies the recorded data to detect defects therein; creates information pointing out to a defect area where a defect occurs and information pointing out to an area which replaces the defect area and stores them as temporary defect information in the memory; controls the recording/reproducing unit to record the data, which is recorded according to the specific recording operation, in specific units after the defect area; reads the temporary defect information from the memory after the data is recorded according to the specific recording operation; and provides the read information to the recording/reproducing unit so that the read information is to be recorded in the temporary defect management area.

FIG. 1

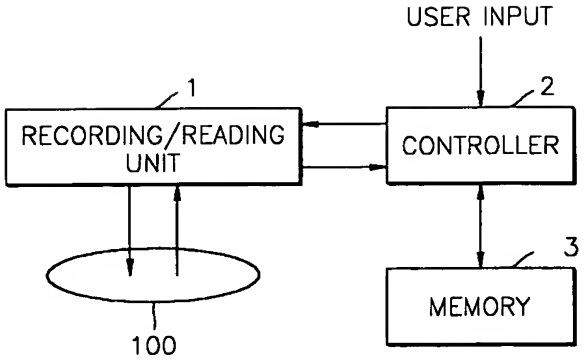


FIG. 2

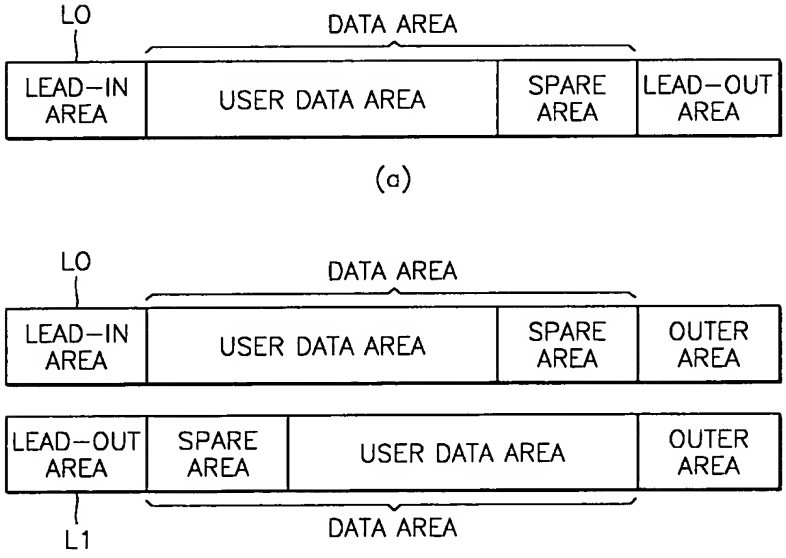


FIG. 3A

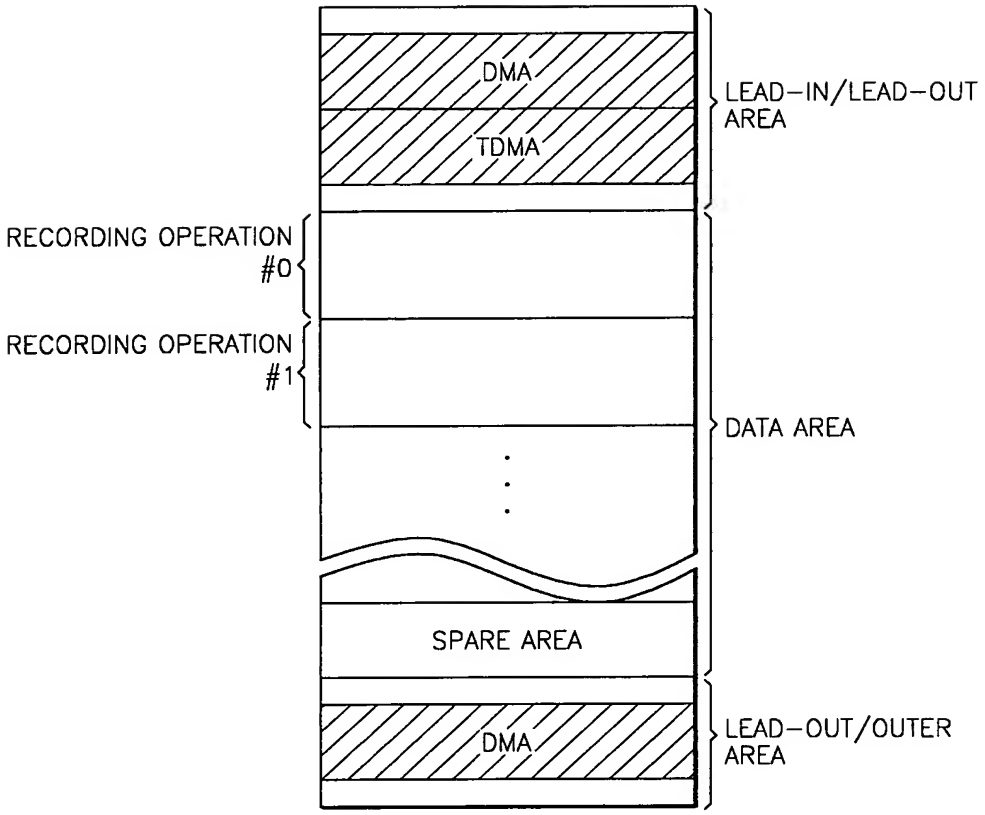

DMA
TDMA
LEAD-IN/LEAD-OUT AREA
RECORDING OPERATION #0
RECORDING OPERATION #1
DATA AREA
SPARE AREA
DMA
LEAD-OUT/OUTER AREA

FIG. 3B

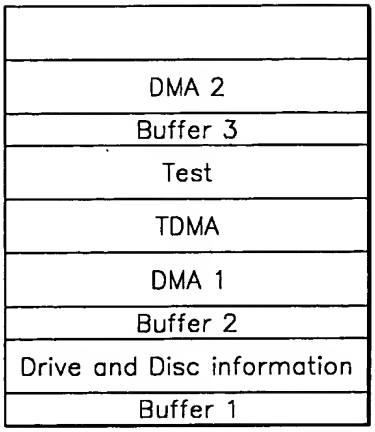

DMA 2
Buffer 3
Test
TDMA
DMA 1
Buffer 2
Drive and Disc information
Buffer 1

FIG. 4A

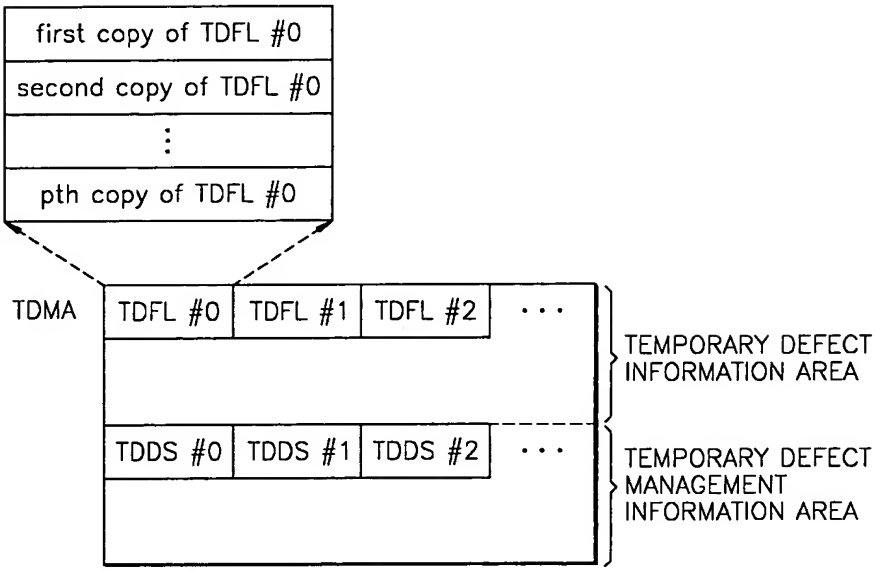

first copy of TDFL #0
second copy of TDFL #0
pth copy of TDFL #0
TDMA
TDFL #0
TDFL #1
TDFL #2
TDDS #0
TDDS #1
TDDS #2
TEMPORARY DEFECT INFORMATION AREA
TEMPORARY DEFECT MANAGEMENT INFORMATION AREA

FIG. 4B

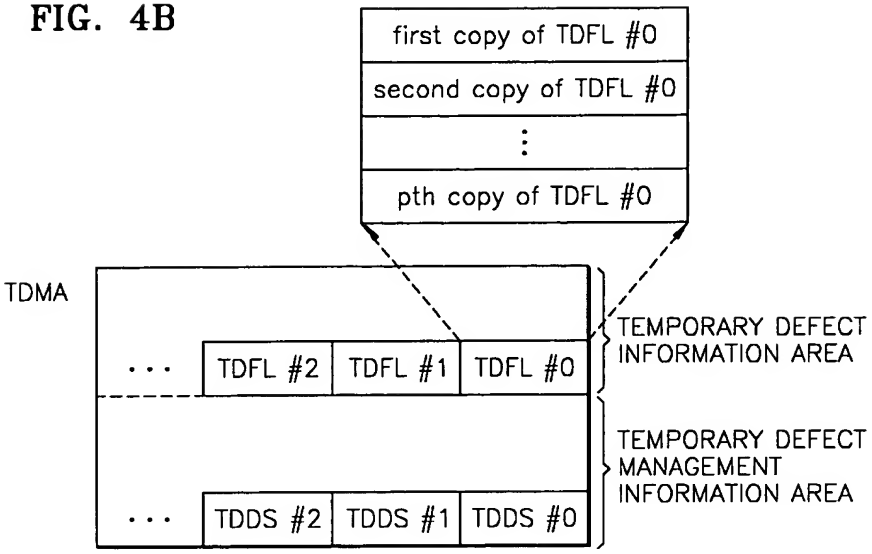

first copy of TDFL #0
second copy of TDFL #0
pth copy of TDFL #0
TDMA
TDFL #2
TDFL #1
TDFL #0
TEMPORARY DEFECT INFORMATION AREA
TEMPORARY DEFECT MANAGEMENT INFORMATION AREA
TDDS #2
TDDS #1
TDDS #0

FIG. 4C

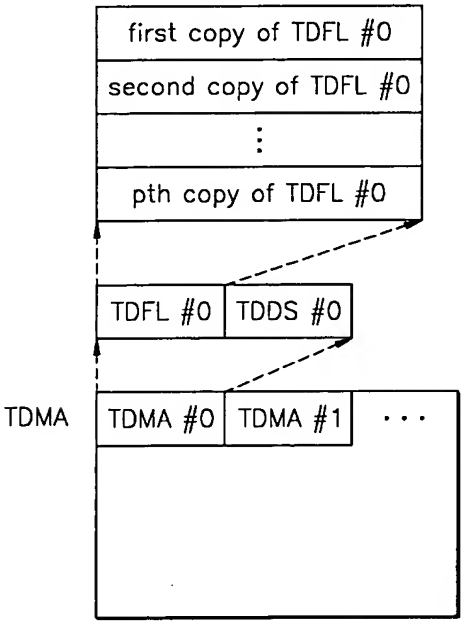

first copy of TDFL #0
second copy of TDFL #0
pth copy of TDFL #0
TDFL #0
TDDS #0
TDMA
TDMA #0
TDMA #1

FIG. 4D

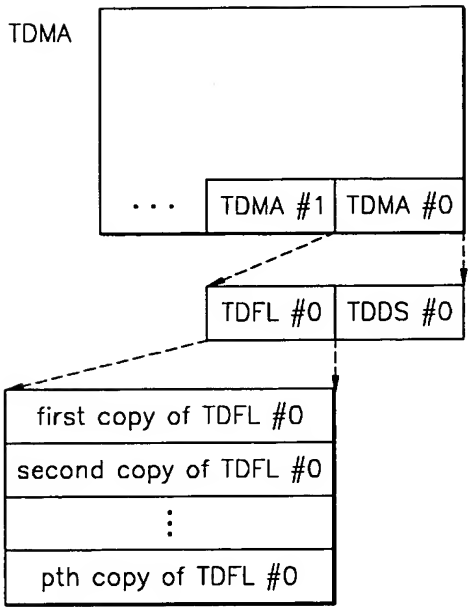

TDMA
TDMA #1
TDMA #0
TDFL #0
TDDS #0
first copy of TDFL #0
second copy of TDFL #0
pth copy of TDFL #0

FIG. 5A

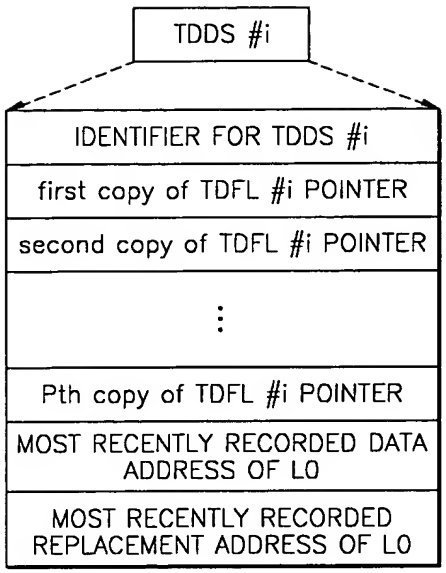

TDDS #i
IDENTIFIER FOR TDDS #i
first copy of TDFL #i POINTER
second copy of TDFL #i POINTER
Pth copy of TDFL #i POINTER
MOST RECENTLY RECORDED DATA ADDRESS OF L0
MOST RECENTLY RECORDED REPLACEMENT ADDRESS OF L0

FIG. 5B

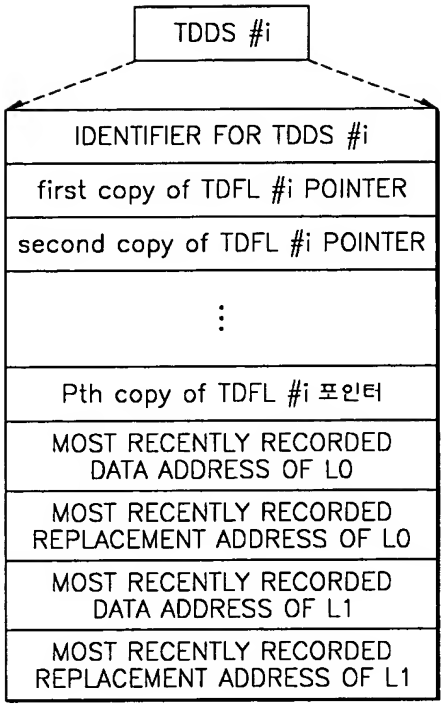

TDDS #i
IDENTIFIER FOR TDDS #i
first copy of TDFL #i POINTER
second copy of TDFL #i POINTER
Pth copy of TDFL #i 포인터
MOST RECENTLY RECORDED DATA ADDRESS OF L0
MOST RECENTLY RECORDED REPLACEMENT ADDRESS OF L0
MOST RECENTLY RECORDED DATA ADDRESS OF L1
MOST RECENTLY RECORDED REPLACEMENT ADDRESS OF L1

FIG. 6

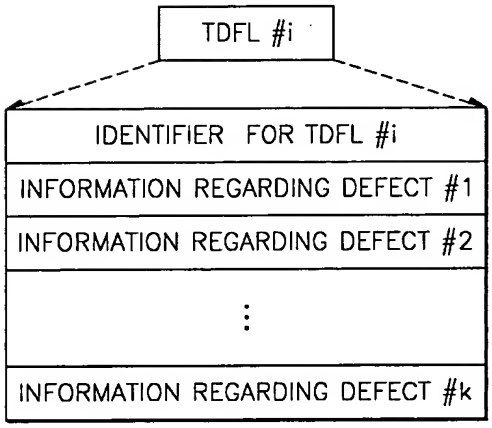

TDFL #i
IDENTIFIER FOR TDFL #i
INFORMATION REGARDING DEFECT #1
INFORMATION REGARDING DEFECT #2
INFORMATION REGARDING DEFECT #k

FIG. 7

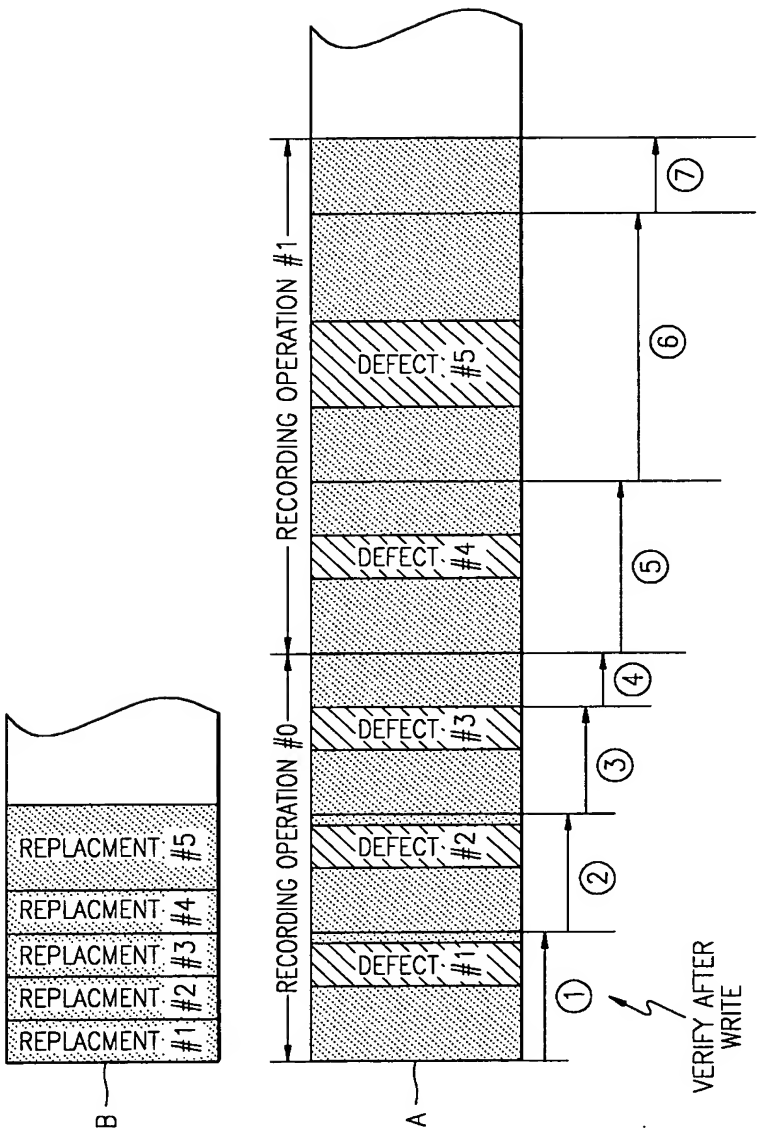

REPLACMENT #5
REPLACMENT #4
REPLACMENT #3
REPLACMENT #2
REPLACMENT #1
B
RECORDING OPERATION #0
RECORDING OPERATION #1
DEFECT #1
DEFECT #2
DEFECT #3
DEFECT #4
DEFECT #5
A
①
②
③
④
⑤
⑥
⑦
VERIFY AFTER WRITE

FIG. 8

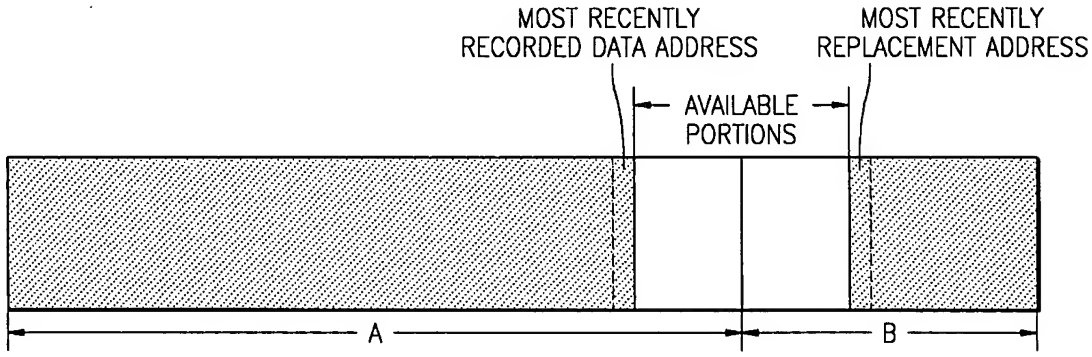

MOST RECENTLY
RECORDED DATA ADDRESS
MOST RECENTLY
REPLACEMENT ADDRESS
AVAILABLE
PORTIONS
A
B

FIG. 9

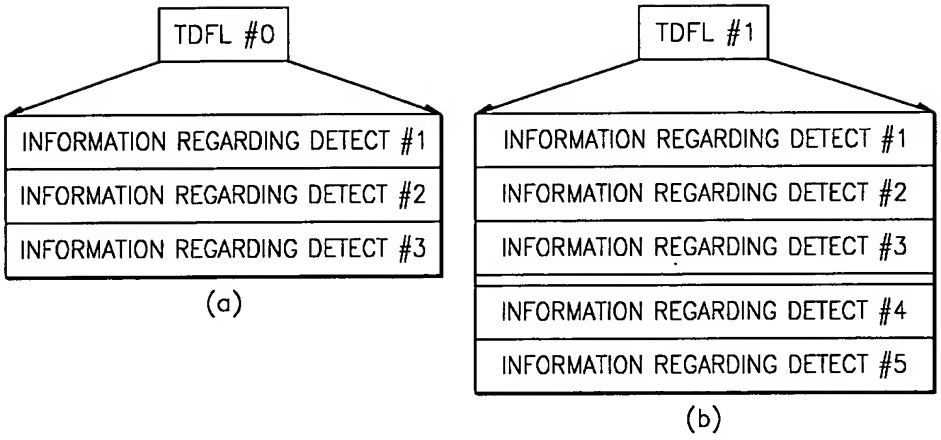

TDFL #0
INFORMATION REGARDING DETECT #1
INFORMATION REGARDING DETECT #2
INFORMATION REGARDING DETECT #3
(a)
TDFL #1
INFORMATION REGARDING DETECT #1
INFORMATION REGARDING DETECT #2
INFORMATION REGARDING DETECT #3
INFORMATION REGARDING DETECT #4
INFORMATION REGARDING DETECT #5
(b)

FIG. 10

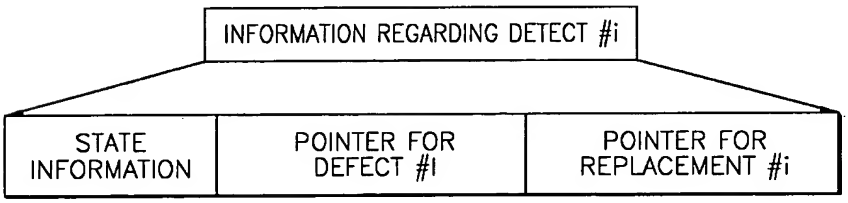

INFORMATION REGARDING DETECT #i
STATE INFORMATION
POINTER FOR DEFECT #I
POINTER FOR REPLACEMENT #i

FIG. 11

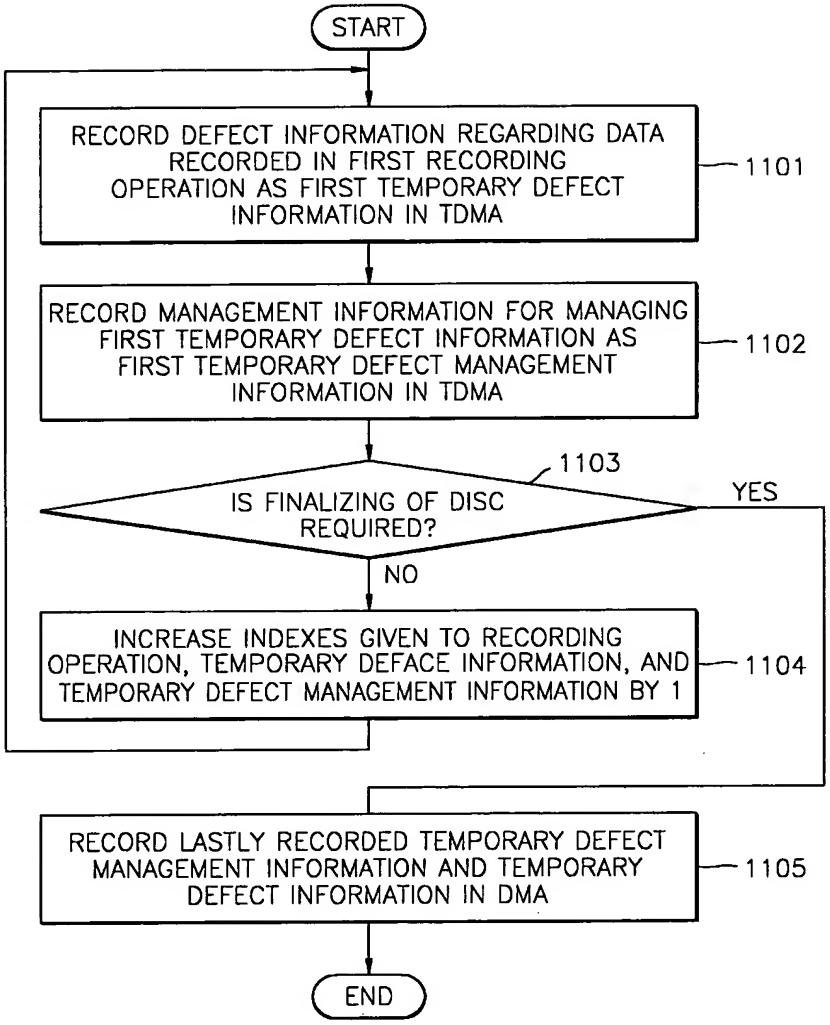
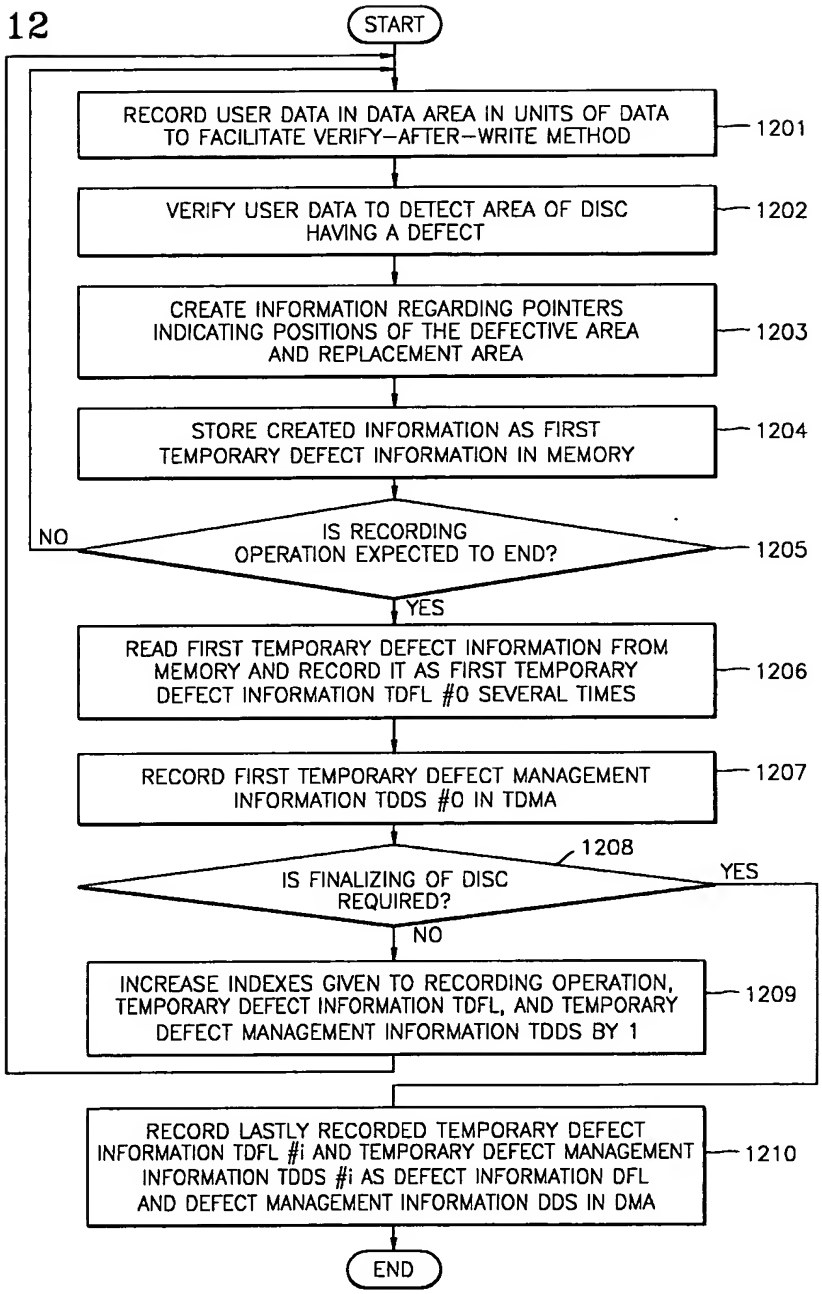

START
RECORD DEFECT INFORMATION REGARDING DATA RECORDED IN FIRST RECORDING OPERATION AS FIRST TEMPORARY DEFECT INFORMATION IN TDMA
1101
RECORD MANAGEMENT INFORMATION FOR MANAGING FIRST TEMPORARY DEFECT INFORMATION AS FIRST TEMPORARY DEFECT MANAGEMENT INFORMATION IN TDMA
1102
1103
IS FINALIZING OF DISC REQUIRED?
YES
NO
INCREASE INDEXES GIVEN TO RECORDING OPERATION, TEMPORARY DEFACE INFORMATION, AND TEMPORARY DEFECT MANAGEMENT INFORMATION BY 1
1104
RECORD LASTLY RECORDED TEMPORARY DEFECT MANAGEMENT INFORMATION AND TEMPORARY DEFECT INFORMATION IN DMA
1105
END

FIG. 12


START
RECORD USER DATA IN DATA AREA IN UNITS OF DATA TO FACILITATE VERIFY-AFTER-WRITE METHOD
1201
VERIFY USER DATA TO DETECT AREA OF DISC HAVING A DEFECT
1202
CREATE INFORMATION REGARDING POINTERS INDICATING POSITIONS OF THE DEFECTIVE AREA AND REPLACEMENT AREA
1203
STORE CREATED INFORMATION AS FIRST TEMPORARY DEFECT INFORMATION IN MEMORY
1204
IS RECORDING OPERATION EXPECTED TO END?
NO
1205
YES
READ FIRST TEMPORARY DEFECT INFORMATION FROM MEMORY AND RECORD IT AS FIRST TEMPORARY DEFECT INFORMATION TDFL #0 SEVERAL TIMES
1206
RECORD FIRST TEMPORARY DEFECT MANAGEMENT INFORMATION TDDS #0 IN TDMA
1207
1208
IS FINALIZING OF DISC REQUIRED?
YES
NO
INCREASE INDEXES GIVEN TO RECORDING OPERATION, TEMPORARY DEFECT INFORMATION TDFL, AND TEMPORARY DEFECT MANAGEMENT INFORMATION TDDS BY 1
1209
RECORD LASTLY RECORDED TEMPORARY DEFECT INFORMATION TDFL #i AND TEMPORARY DEFECT MANAGEMENT INFORMATION TDDS #i AS DEFECT INFORMATION DFL AND DEFECT MANAGEMENT INFORMATION DDS IN DMA
1210
END